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# Evaluation of remote-start pump systems for use in wildfire/structure protection

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# Table of Contents

# Introduction

Previous research (Walkinshaw and Ault 2008/9) has showed that sprinkler systems can improve structure protection if water is applied in advance of a wildfire. Traditionally, sprinkler systems had to be started and stopped manually; however, technology now exists to start these systems remotely using either radio frequency (RF) or cellular/satellite networks. A remote-start system allows owners and agencies to protect private property and assets from a distance without compromising safety.

The remote-start pump concept was conceived by USFS San Dimas Research Center in 2002 (Cammack 2002) and was commercialized by Wildfire Environmental Inc. A remote-start system can be used with sprinkler systems to provide structure protection or can be adapted for pump relay applications. Controlling the pump start can minimize water damage sustained by structures and can conserve limited water and fuel supplies. This study evaluated the usability and effectiveness of two remote-start systems. The evaluation focused on the remote-start operation only and not the pump or engine operation. FPInnovations researchers collaborated with staff at the Ontario Ministry of Natural Resources (OMNR), Pump Systems in Thunder Bay, ON.

# Objectives

1. Determine the remote-start technology available and acquire these products for an evaluation.
2. Evaluate selected products by conducting:
   a. range tests to determine how far away remote starters can activate the pumps
   b. operational reliability tests to determine cold start performance, priming success, pumping success, engine start, and operator feedback.
3. Assess the overall product usability by observing of use of the control system and documenting operator feedback.

# Methods

## Review of Available Technologies

A remote-start pump system is comprised of a remote-start control, an interface on the pump and a pumping system. An internet search for remote-start pump systems in August 2008 and in September 2010 identified only two systems suitable for wildfire application. Systems with electric pumps were not considered unless they had their own power as it was important for the system to work when the electric power grid was unavailable. The two systems identified as suitable for wildfire application were:

- BB4 pump, Remstar control module and Omnistar remote device
  Wildfire Environmental Inc., Lachine, QC

www.wildfire-environmental.com

- Wireless Remote Propane Fire Pump
  Wildfire Sprinkler Inc., Grand Marais, MN
  www.wildfiresprinkler.com

### *Remstar BB4 Pump System - Wildfire Environmental Inc.*

The Remstar remote-start system can be added to any BB4 electric start pump unit with either an 18 hp or 23 hp Briggs & Stratton Vanguard petroleum powered engine. The system consists of the Remstar control module, REM-100 BB4 Wire Harness Installation Kit, and the BB4 pump. The REM-100 Installation Kit contains modifications to the BB4 pump to allow remote operation. These added kits/functions are Starter Solenoid Kit, Choke Solenoid Kit, Check Valve Kit, Engine Wire Harness Kit, Battery Kit, and Electric Primer Kit. Note, once the pump is modified with the REM-100, it can be used with either the Remstar or Omnistar remote devices. Although not available at the time of the test, a REM-700 Remstar Phone Option is now available that allows pump control over cellular or satellite phone options. The pump and the Remstar control box are shown in Figure 1.

The budgetary price[1] (31 December 2009) for the system:

| | |
|---|---|
| Remstar Module | $2 851 CDN |
| BB4 Remstar Ready | $7 040 CDN |
| REM-100 Modification Kit for existing BB4 | $1 652 CDN |
| REM-700 Remstar Phone Option | $1 584 CDN |
| REM-600 Strobe Option | $ 340 CDN |

### *Remote Propane Pump System - Wildfire Sprinkler Inc.*

The Wildfire Sprinkler Inc. remote-start propane pump system is a modified Davey single stage impeller pump Model 5160B with electric start and a Remote Anything control system. The pump is modified to work on propane fuel with standard propane cylinders. The pump was designed to operate a homeowner protection sprinkler system. The pump is shown in Figure 2.

The budgetary price (31 December 2009) for the system:

| | |
|---|---|
| Wildfire Sprinkler Inc. Propane Pump | $3 200 USD |

[1] Budgetary price is a non-binding price provided for planning purposes, usually within 10%. It is not contractually binding and needs to be confirmed with a formal quote.

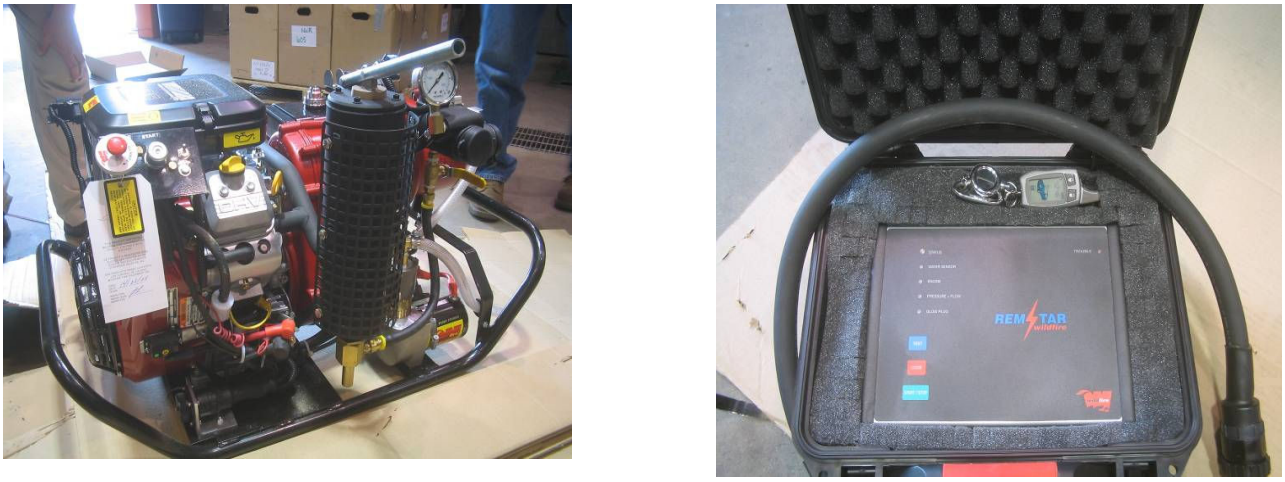


**Figure 1. Remstar modified BB4 pump and Remstar control box from Wildfire Equipment Inc.**

### *Wildfire Environmental Inc. Omnistar Tandem Pumping Accessory*

The Omnistar Tandem Pumping Accessory is a remote device that starts an inline pump used in a tandem pumping setup when water arrives at the pump and stops the pump when the input water stops. The system electrically hooks into the same connector on the BB4 pump as the Remstar. The Omnistar setup is independent and once armed, works without intervention to start or stop the inline pump. Multiple units can also be placed in line to pump water long distances with only an operator at the source end (and no operators if a Remstar pump is used at the source) as illustrated in Figure 3. The Omnistar system must be used with a Remstar modified BB4 pump. The Omnistar control box is shown in Figure 4.

The budgetary price (31 December 2009) for the systems:

| | |
|---|---|
| Omnistar Module | $1 584 CDN |

**Figure 2. Modified Propane Pump by Wildfire Sprinkler Inc.**

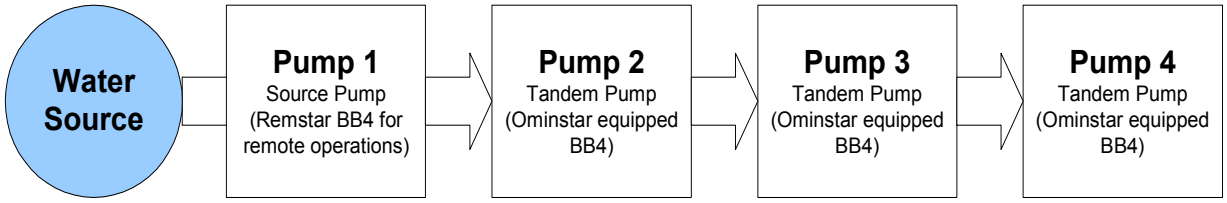


**Figure 3. Tandem pumping with Omnistar Tandem Pumping Accessory.**


**Figure 4. Omnistar control box by Wildfire Equipment Inc.**

### *Remote Control Devices*

Remote control devices are used in many industry sectors. The "car-starter" technology with small radio frequency (RF) devices for activation is common. Stand alone remote kits can be added to control most electrically activated devices. Range for RF signals is usually short and must be within line of sight. The two products evaluated in this study used a "key fob" device which sends RF signals to the target device to initiate a function. Other more advanced and expensive systems now exist, such as modems to activate a controlling relay or cellular/satellite connections to give infinite coverage allowing remote control from computing devices (laptops, smart phones). In most of these cases, the technology and the constituent component parts exist, but an integrated unit that combines the components into one system for wildfire protection does not.

## Evaluations

These evaluations were limited to the remote-start application only. Neither the pump nor the engine was evaluated in this study.

### *Range (ground; flat terrain)*

To determine range on flat ground, an operator slowly moved away from the pump and periodically activated the start sequence with the key fob controller. The operator continued this

process until the pump no longer responded. This distance in metres was recorded. The activation was repeated at further distances and at the maximum distance to confirm the result. This test was repeated 3 times.

### *Range (air)*

To determine range from the air, an operator activated the start sequence from a helicopter. A GPS unit was used in the helicopter to get a straight line distance to the pump. The operator activated the start sequence using the remote control at 0.5 km increments until the pump did not respond. Both pumps were placed next to each other on the ground at the test site and activated at the same time from the same helicopter position. This test was line of sight so the pumps were visible from the aircraft at all times. This test was performed only once due to helicopter availability and cost.

### *Cold Start*

To determine the cold start performance, the pumps were started remotely each morning. Pump start success and the number of start attempts were recorded. This test was repeated 3 times.

### *Pump Priming*

The time required to prime each pump start cycle was recorded. This test was repeated 3 times.

### *Fuel Starvation*

To determine the performance after fuel starvation, the fuel line was removed when the pump was running and subsequent pump activity was recorded. This test was repeated 3 times.

### *Prime Loss*

To determine the performance after loss of the water prime, the suction hose was removed from the water source while the pump was operating and subsequent pump activity was recorded. This test was repeated 3 times.

### *Stand-by Battery Consumption*

An ammeter was attached to the battery's positive terminal and the current draw in stand-by mode was recorded. This value was divided into the amp/hour rating of the battery to give the maximum time the battery could run the system. This time was derated by 50% to allow for engine start and battery age. This test was repeated 3 times.

### *Fuel Consumption*

For the BB4, the time the pump would run on 1 litre of fuel was recorded. The result was then extrapolated to tank size. For the propane pump, the fuel tank was weighed prior to pump start. The pump was allowed to run for one hour and the tank re-weighed. The result was extrapolated to the tank size. This test was only repeated once due to the time involved.

### *Usability of Controller*

To determine the usability of the controller, researchers recorded the electronic feedback given to the operator by the remote control device as well as the inputs necessary to operate the pump remotely. These observations were recorded throughout the entire study.

### *Tandem Pumping*

Researchers observed the operation of a tandem pump set-up, which consisted of a standard Mark III fire pump at the water source, pumping into 189 m (400 feet) of 1 ½ inch hose, leading to the Remstar modified BB4 pump with the Omnistar Tandem Pumping Accessory. The output of the BB4 was connected to 94.5 m (200 feet) of hose ending with a fog nozzle to introduce pressure. Observations of how the Omnistar-equipped BB4 pump responded automatically to water inputs arriving at the pump and its response when the water stopped flowing to the pump were recorded. This test was repeated 3 times.

# Results

## Evaluations

The testing took place on 20-21 August 2008 at the Ontario Ministry of Natural Resources (OMNR) nursery in Thunder Bay, Ontario. The test setup is shown in Figure 5.

**Figure 5. Remote start pump test setup at OMNR nursery, Thunder Bay, ON.**

### *Range (ground and air)*

The results from the ground and air range tests are summarized in Table 1. A clear line of sight was maintained between the pumps and the transmitters in both cases. Antenna orientation was observed to be important when the devices were at their range limits.

The propane pump had an external antenna that could be lifted or mounted above the ground on a pole up to 8 feet high, which increased its range. The external antenna was a directional dipole

and its orientation was critical for the ground range, as performance decreased when the dipole was in line with the pump.

The Remstar pump had an antenna integrated into the lid of the control box and because of the cable length it could not be elevated above ground. The remote start worked better when the control box lid was open; however, a closed lid is preferred for remote applications.

Neither pump met the manufacturers' specified range values for ground operation during the test.

**Table 1: Operational and manufacturer's specified range for remote pump operation using the supplied key fob device.**

| Pump | Manufacturer's Specified Range (m) | Average Ground Range (m) | Average Air Range (m) |
|---|---|---|---|
| Remstar | 914 | 425 | 2,000-2,500 [a] |
| Propane | 762 | 290 | 3,000 [a] |

[a] *Slant distance, altitude above ground level ~500 m (1500 feet)*

### *Cold Start*

The cold start test was performed in the morning after the pumps had been idle overnight. Both pumps started on the first attempt when setup as per the manufacturers' instructions. The Remstar has the logic to try three times on each commanded start cycle.

### *Pump Priming*

The Remstar had a priming pump which filled the pump chamber in 1-2 second(s), just prior to each engine start. The time to prime was the same whether the pump housing was full or empty.

The propane pump was self-priming but took up to one minute when the pump body was empty. Once the pump housing was full, the pump primed quickly.

### *Fuel Starvation*

When the fuel line was disconnected and the engine allowed to run until it stopped, the Remstar pump attempted to restart two more times (unsuccessfully as there was no fuel) and then signaled the key fob that an error had occurred. The propane pump merely shut down and provided no feedback to the operator. When the fuel line was reconnected, both pumps started normally.

### *Prime Loss*

When the water prime was lost by removing the suction hose from the water source, the Remstar pump sensed that water was no longer present and stopped the pump. It then attempted to restart by repeating the sequence. The prime action ran for a considerable time after which the engine starter engaged and started the engine. Because the input conditions of water pressure, water flow and engine vibration were not met, the pump immediately shut down. The start sequence repeated one more time and then the controller signalled the key fob that an error had occurred.

A special condition was observed when using a hose strangler (a device used to clamp a hose to stop water flow to allow the changing of attachments) with the Remstar system. The pump stopped when the strangler was applied and did not restart successfully because there was no water flow in the system. However, a bypass system could be used with a hose strangler to ensure water continues to flow in the system.

The propane pump continued to run when prime was lost, as there were no sensors to detect the condition and stop the pump. There was no remote method of shutting off the pump. This could lead to potential damage to the unit if left to run for an extended period without prime. The manufacturer stated that this functionality could be added to the unit but this was not available on the pump that was evaluated in this study. Researchers also found that if there was back pressure at the pump, caused by elevation from an uphill hose run, the pump would not prime. This was due to the flapper one-way valve inside the pump body. Although this issue could be avoided through the use of pressure bleed devices or check valves; it was not deemed important as this pump is usually permanently installed in a residential application.

### *Stand-by Battery Consumption*

This test determined how long the units could stay in stand-by mode (ready to operate and waiting for a remote-start command) and still have enough power to start the pump. The stand-by time was based on the current draw by the device while in stand-by mode and was calculated using the capacity of the battery supplied with the pump. The battery's capacity was de-rated by 50% so that half of the battery's capacity would be available to start the engine. Table 2 summarizes the results for the tested systems.

**Table 2: Measured stand-by currents and calculated stand-by times for the tested remote-start pumps.**

| Equipment | Battery 12 VDC (Ah) | Stand-by Current (mA) | Calculated Stand-by Time (hours (days)) | 50% De-rating for Start (days) |
|---|---|---|---|---|
| Remstar BB4 | 19 | 95 | 200 (8) | 4 |
| Omnistar BB4 | 19 | 100 | 190 (8) | 4 |
| Propane Pump | 30 | 19.5 | 1538 (64) | 32 |

### *Fuel Consumption*

The Remstar BB4 fuel consumption was 5.2 litres per hour. The integrated tank was 2 gallons or 7.5 litres, giving an estimated operating time of 1.4 hours. The standard external 20 litre tank would last about 4 hours.

The propane pump consumed 2 pounds of propane per hour. With the standard 20 pound tank, the pump would run for approximately 10 hours. Both pumps were capable of using a larger tank if desired.

### *Usability of Controller*

The BB4 pumps equipped with Remstar/Omnistar options were easy to operate. The Remstar/Omnistar control boxes at the pump had LED indicators to show the status of the pump operation and aided in troubleshooting. These LED status indicators were fully explained in the user manuals; however, the user manuals failed to clearly explain the functions or displays of the key fob controller. An optional flashing strobe light on the pump indicated pump function and was visible from the air. The logic of the overall remote system was easy to understand which further aided in troubleshooting. The remote key fob for the Remstar system provided feedback to the operator regarding communications, pump status and error conditions. Some of this feedback consisted of audible beeps (eg. signalling a successful start) which were hard to hear in a helicopter. The feedback to the operator is not immediate, and since the same button starts and stops the unit, additional button presses are possible if the operator is impatient. A recent update to the user manual (not available at the time of this study) provides better instructions for both pump operation and the key fob.

The propane pump was a very simple system. There were no indicators on the control box at the pump. When the system was activated using the remote key fob, there was no feedback to the operator that the pump had started. There was no function to shut down the pump remotely; the pump must be stopped manually with a switch on the pump unit. Researchers noted a grinding noise in the pump/engine unit when the remote start button was 'accidentally' pressed while the pump was already running, suggesting possible damage to the system. Remote stop functionality was not incorporated in the tested system, but could be implemented if desired.

### *Tandem Pumping*

The BB4 pump with the Omnistar Tandem pumping set-up performed as specified. When the remote pump with Omnistar received water from the source pump, the pump activated and sped up to the preset throttle position. When the water was stopped at the source, the pump shut down. When flow and pressure returned, the pump re-started. It is important to set the throttle correctly and to test the system prior to use, as the in-line pump is capable of flattening the input hose if the throttle is set too high.

## Discussion

Both of the remote-start systems tested in this evaluation met manufacturers' claims for start reliability and function. Adverse characteristics of the pumps identified in these tests (flapper valve, ground range, strangler, etc.) could be mitigated during installation, as long as the installer was aware of these characteristics. The tests showed that both pumps were capable of remotely starting and operating in a wildfire situation.

The Wildfire Environmental Inc. Remstar BB4 pump was well designed and engineered. It incorporated logic circuits to start the pump and perform the necessary start functions of engine choke and pump priming. If starting was unsuccessful because of water pressure, water flow or engine start, the pump would shut down and start the cycle over again. It would do this three times before declaring a fault. The larger engine and pump would be capable of multiple sprinkler heads and a tandem operation if longer distances were required.

The Wildfire Sprinkler Inc. propane pump was a much smaller unit but sufficient for homeowner applications. The pump system evaluated in this study suffered from some quality issues, specifically with wiring, but researchers were assured that this was an evaluation pump only and that production units would be better. The pump started quickly and reliably, and could be easily adapted to a much larger residential propane tank for extended operation.

Neither pump met the range specifications for ground operation with the key fob control device. Although every attempt was made to mount and orient external antennas correctly, this was likely the main cause for the observed range distances. For each installation, users will need to carefully take into account the terrain and surrounding obstacles when placing the antenna. With the cellular/satellite/modem options now available, the pump system could be started from any location as long as both the pump and the activating device have communication coverage. This would allow homeowners to evacuate their property, but still be in control of the pump for wildfire protection.

The operation and use of these pumps was discussed with the OMNR technicians involved in the tests. All were impressed with both the reliability and the quick remote-start capability. However, OMNR wildfire staff explained that in a typical Ontario wildfire situation, one could merely land the helicopter, jump out and start the pump. Since an operator needs to be close (~2 km) to use a radio frequency remote-start system, it was deemed unnecessary. However, remote-start pump systems using cellular/satellite/modem technology would make the use of these systems much more practical. A remote-start option can save time and can reduce the risk of injury to firefighters and helicopter pilots by eliminating the need to land in front of an advancing wildfire.

## Conclusions

This study demonstrated that reliable remote-start pumping systems to operate sprinkler systems as a means of protecting structures against wildfire damage are available in the marketplace. The Wildfire Environmental Inc. BB4 pump system was the more robust of the two systems tested and allowed more advanced control of the system, whereas the Wildfire Sprinkler Inc. propane pump was smaller and a start-only system.

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